

This **Temperature-Probe Assembly** floats on a body of water. The metal sleeve at the middle hangs down into the water. Temperature probes are mounted inside the sleeve for measuring temperatures at several different depths.

2.5 in. ( $\approx 6.4$  cm) in diameter. The disks are stacked to form cylinders, bolted to the rod, and covered with hollow plastic sleeves. A metal sleeve is clamped to the middle of the aluminum rod, from whence it hangs down into the water. Temperature probes (which can be thermocouples, thermistors, or resistance temperature devices) are placed within the sleeve at the desired measurement depths. Wires from the temperature probes are routed to the input terminals of a data logger.

*This work was done by Randy Stewart of Lockheed Martin Corp. and Clyde Ruffin of GB Tech, Inc., for Stennis Space Center. Further information is contained in a TSP [see page 1].*

*Inquiries concerning rights for the commercial use of this invention should be addressed to the Intellectual Property Manager, Stennis Space Center [see page 1]. Refer to SSC-00136.*

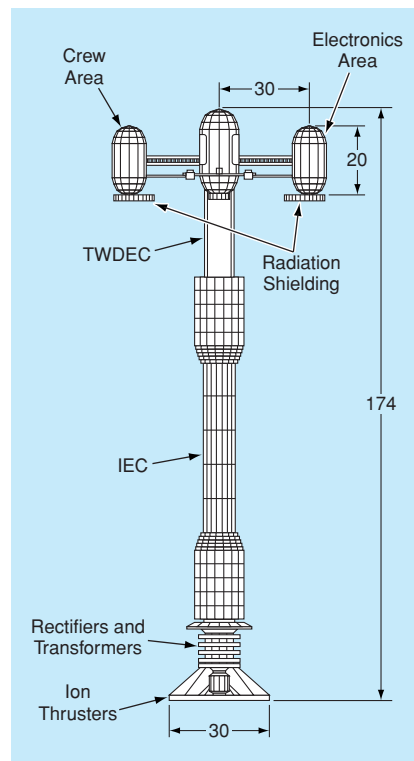
## Proton Collimators for Fusion Reactors

High-energy protons would be channeled into useful beams.

Proton collimators have been proposed for incorporation into inertial-electrostatic-confinement (IEC) fusion reactors. Such reactors have been envisioned as thrusters and sources of electric power for spacecraft and as sources of energetic protons in commercial ion-beam applications. An artist's concept for an IEC powered spaceship designed for round trip missions to Mars and Jupiter is shown in the figure.

An IEC fusion reactor typically contains a plasma of pure  $^2\text{H}$  or a  $^2\text{H}$ - $^3\text{He}$  mixture. Collisions among the  $^2\text{H}$  and/or  $^3\text{He}$  nuclei give rise to fusion reactions, the main energetic products of which are protons with kinetic energy  $\approx 14$  MeV and an isotropic velocity distribution. A proton collimator would collect the isotropically emitted protons and form them into a collimated beam.

A proton collimator would include (1) an electromagnet outside the fusion reactor that would impose a substantially uniform magnetic field within the reactor and (2) a pair of electromagnet coils inside the reactor, oriented to generate magnetic fields antiparallel to the one generated by the external electromagnet. The interior electromagnet coils would be positioned so that the fusion reaction would be concentrated in a region between them. The currents in the interior electromagnet coils would be adjusted to minimize the net magnetic field in the fusion-reaction region in order to avoid any adverse



A scale schematic of **100-MWe IEC Fusion-Powered Spacecraft** is depicted with dimensions in meters. (Note TWDEC = Traveling-Wave Direct Energy Converter.)

effect of the magnetic field on the trajectories of the  $^2\text{H}$ - $^3\text{He}$  ions that must collide to cause

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fusion reactions. The accessible region for the ions and electrons can be completely separated from inner electromagnet coils and support the structure, preventing bombardment damage.

The overall effect of the electromagnets would be to channel the isotropically emitted 14-MeV protons into a beam substantially parallel to the magnetic field. The collimator would also separate the 14-MeV protons from unreacted fuel ions leaking out of the reaction region. The leaking fuel constituents would be collected on plates, condensed to a gas, pumped out, and recycled to the reactor.

The collimated proton beam could be used directly for spacecraft thrust or an industrial ion-beam application. Alternatively, the proton collimator would be used in conjunction with a magnetic expander and an electron/ion separator to generate a net electric current. Another approach under consideration for space propulsion is to focus the beam on a target, e.g., a small plastic pellet, which would be vaporized and exhausted through a magnetic nozzle. Yet another alternative is to introduce the beam into a highly efficient traveling-wave energy-conversion device to extract electric power.

*This work was done by George H. Miley and Hiromu Momota of NPL Associates, Inc., for Marshall Space Flight Center. Further information is contained in a TSP [see page 1]. MFS-31734*